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INFORMATION CIRCULAR

SOAPSTONE

BY

H. HERBERT HUGHES

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February, 1932

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

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By H. Herbert Hughes[2]

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INTRODUCTION

Soapstone commonly is associated with talc, and reports on either commodity usually contain a discussion of the other. From a geological or mineralogical standpoint the combination is justifiable, for soapstone essentially is impure talc. Commercially, however, the relation between them is remote. About 95 per cent of all talc sold in the United States is in ground form, whereas practically all soapstone is sold as furnace blocks or as fabricated structural slabs for many and diverse applications.

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1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6563."

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Most of the ground talc consumed in the United States is sold for purposes where the white color, slip, fineness of grinding, and lack of grit give the product decided advantages over other pulverized rocks. Some waste soapstone from fabricating plants is ground and marketed in competition with talc. This condition, however, exists only when the material is to be used for nonspecialized purposes. Furthermore, in these markets soapstone is in direct competition with ground limestone, whiting, slate flour, and similar products.

Many deposits of high-grade talc contain local segregations of impurities which lower the quality of the material and make it unsuitable for sale as first-quality talc. This product is comparable to ground soapstone, and there is some overlap in this market between talc and soapstone. This overlapping, however, is insignificant when contrasted with the total volume of either talc or soapstone production.

The soapstone industry in the United States is largely in the hands of one company, the Virginia Alberene Corporation, with mills and quarries at Schuyler, Va. The purpose of this paper is to describe briefly the properties, uses, and methods of quarrying and manufacture of soapstone, as well as general conditions in the industry. The help of the officials of the Virginia Alberene Corporation is acknowledged.

DEFINITION

Theoretically, talc is a hydrous metasilicate of magnesium with a definite chemical composition, expressed by the formula $H_2Mg_3(SiO_3)_4$. Actually, however, the silica or magnesia content may vary as much as 3 or 4 per cent with little change in the appearance of the mineral. Iron oxide is the principal impurity. Talc commonly is called steatite or soapstone, but these terms apply more accurately to modifications of true talc. Steatite usually is defined as massive talc that may be used in block form; French chalk is the most common example. Soapstone, in its original sense, apparently was synonomous with steatite. Agalmatolite is a name given to both massive talc and massive pyrophyllite, but it more properly should be reserved for the latter.

At present, proper usage demands that the term "soapstone" shall include all massive gray to bluish or greenish talcose rocks which, with few exceptions, have a soapy feel and can be carved easily with a knife. Practically all soapstone which has been produced commercially is in reality a metamorphic rock, composed of only 50 to 80 per cent of talc (hydrous metasilicate of magnesium) intimately mixed with varying proportions of chlorite, amphibole, pyroxene, and mica, as well as pyrite, quartz, calcite, or dolomite. Soapstone, therefore, generally is a rock rather than a mineral, although the term may be used accurately to refer to massive talc, however pure. Regardless of the indefinite mineral composition of the material, however, analyses of typical samples reveal that the magnesia content of commercial-grade soapstone is at least 20 per cent. A parallel situation exists with limestone and calcite. A bed of impure limestone containing only 60 to 75 per cent of calcium carbonate can not be called calcite, although a deposit of pure calcite may justly be designated as limestone.

This paper is concerned only with soapstone, and throughout this discussion the term will be used as it properly is applied in present-day commercial nomenclature.

HISTORY

Probably the earliest known uses of soapstone were dependent upon the ease with which it could be cut. Early Egyptian scarabs and amulets were carved steatite coated with a blue vitreous glaze. The Assyrians used it for signets, and numerous carbed steatite ornaments were found among ruins in Rhodesia. For centuries the Chinese and Japanese have carved weird figures out of steatite or agalmatolite; the handiwork of the present generation may be purchased in any Oriental curio shop.

The cathedral of Trondhjem, Norway, was built about 1200 A. D. of soapstone from Gudbransdal. The structure recently was rebuilt to repair damage due to vandalism and fire, but otherwise the stone is in good condition. It has hardened considerably since the building was first erected. Steatite found in association with serpentine near Cornwall, England, was used in the manufacture of old Worcester porcelain.

Soapstone was first used in the United States by the American Indians, who early recognized its heat-retaining qualities. Soapstone bowls, pots, cooking stones, and other utensils made by the Indians are on display in many museums. This utilization gave rise to the term "potstone," which still is applied to soapstone in some localities.

The deposit of soapstone in Albemarle County, Va., was first opened on a semicommercial scale about 1880. From then until now the history of the soapstone industry parallels that of the Virginia Alberene Corporation. John G. Porter was responsible for the development of the deposit, and the present company is a direct outgrowth of his early activities. Soapstone has been produced from this deposit for more than 50 years.

The original quarries were located at Alberene, Va., but present activities are centered at Schuyler, just across the Albemarle County line in Nelson County. Several quarries are operated. The exact number as well as their output is directly dependent upon demand, but the usual average is four or five.

Other States have produced soapstone, but Virginia has dominated the industry. In 1913, there was 1 producer each in Maryland, North Carolina, and Rhode Island; 2 in Vermont; and 6 in Virginia, the latter State producing more than 85 per cent of the total. The following year Virginia produced 15 times as much soapstone as the other four States, and in 1915, 23 times as much. Production in 1916 was virtually all from four quarries in Virginia, although California and Rhode Island reported activity. The entire output for the following year was from three Virginia quarries. For the next three years Vermont and California reported sporadic production, but in 1921 the Virginia Alberene Corporation was the only producer of any consequence.

From 1922 to 1926 four new companies in Virginia and one in North Carolina were organized to exploit soapstone, but in 1927 only one company remained active. Meager reports from California indicate that in 1923 soapstone from Oroville, Butte County, Calif., was being shipped to chemical plants in the San Francisco district. Later information, however, has intimated that this material may have been talc rather than soapstone. Since 1929, the product of the Virginia corporation has been the only soapstone extensively marketed, although locally small quantities of similar material may have been produced.

COMPOSITION AND PROPERTIES

Soapstone is typical of all metamorphic rocks in that its chemical and physical properties may vary considerably. Since talc is the essential mineral of soapstone, analyses of most samples show some resemblance to the theoretical composition of talc, which is: SiO_2, 63.5 per cent; MgO, 31.7 per cent; and H_2O, 4.8 per cent. Iron oxide, alumina, and lime are the other principal constituents of soapstone. Results of analyses made by Mellon Institute of seven samples of soapstone are summarized in the following table.

Chemical Composition of Soapstone[1]

	Maximum	Minimum	Average
Silica	40.20	34.12	36.11
Alumina	9.10	5.45	6.78
Iron oxide ..	11.75	8.84	9.96
Lime	6.39	3.19	3.99
Magnesia	29.03	23.69	26.48
Titania	0.48	0.28	0.35
Alkalies	0.37	0.13	0.23
Ignition loss	18.36	8.44	14.87

1 - Courtesy of Virginia Alberene Corporation.

Soapstone which contains no carbonate impurities is comparatively inert; chemically even at high temperatures it resists the action of strong acids and alkalies. The durability of the stone depends upon this same property. Although some grades may be easily abraded, soapstone shows little or no deterioration when exposed to weathering agencies, even for very long periods.

Soapstone is a dense, massive, fine-grained rock. It varies in color from light gray through shades of blue to dark blue with occasionally a greenish cast. The average weight of commercial stone is about 180 pounds a

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cubic foot, which is equivalent to a specific gravity of nearly 2.9. It is virtually nonabsorbent; in fact, most soapstones show an absorption by weight of less than 0.1 per cent. Locally, the stone may be fractured or may lack uniformity. The deposits, however, have no regular system of joints or cleavage, although the grain of the rock usually is pronounced. Soapstone has little tendency to split or spall.

The hardness of soapstone varies considerably; that now being produced commercially is divided into three grades: soft, regular, and hard. The soft stone is typical of the usual conception of soapstone. It is soft enough to be scratched with a finger nail, but its strength is satisfactory for numerous uses. The hard grade contains a sufficiently high percentage of siliceous material to make it considerably harder and more durable than common soapstone. It is best suited for stair treads, floor tile, and similar uses. The so-called regular grade is by far the most abundant. Its properties are midway between the hard and the soft, and virtually all fabricated soapstone equipment with interlocking joints is made of this quality of stone.

The ease of workability is the most valuable characteristic of soapstone. Its comparative softness and its massive uniformity combine to make it the most easily fabricated of all natural stones. It may be tongued, grooved, trimmed, or bored with ordinary woodworking tools. Regardless of these characteristics, however, soapstone has remarkable transverse and compressive strengths. The following table gives a summary of tests made of representative soapstone samples.

Physical Strength of Soapstone[1]

Thickness of sample,[2] inches		Fibre stress per square inch at rupture, pounds					
		Transverse strength			Compressive strength		
		Soft	Regular	Hard	Soft	Regular	Hard
1	Maximum	2190	2590	4120	5200	7000	14300
	Minimum	1930	2530	3730	3300	6100	8900
	Average	2060	2560	3930	4150	6580	11420
1¼	Maximum	2200	4250	3110	3800		
	Minimum	2050	2550	2630	3500		
	Average	2140	3400	2870	3650		
1½	Maximum	2390	3000	3670			
	Minimum	2160	2680	3050			
	Average	2310	2840	3370			
2	Maximum	3420	3960	3590	8000	15300	11300
	Minimum	1870	2930	3010	3100	6300	5100
	Average	2640	3450	3300	4650	9880	8530
Average of all samples		2290	3060	3370	4320	8230	9980

1 - Courtesy Virginia Alberene Corporation.

2 - Samples for transverse tests 4 by 14 inches, supported on knife edges, 12-inch span, loaded at center; samples for compressive tests, cubes cut from transverse test samples.

Soapstone takes up heat slowly, but once hot it tends to hold its absorbed heat considerably longer than other natural stones. For all practical purposes it is fireproof, but, upon heating to a temperature of about 1,800° F., it changes color and becomes quite hard. The specific heat and the dielectric strength of soapstone are unusually high. All these properties are utilized in various specialized applications of the stone.

USES

The various uses of soapstone are related to both its chemical and its physical characteristics. Several of the most common uses are dependent upon its comparative chemical inertness, some upon a combination of chemical composition and physical properties, and others have no direct relation to either.

The chemical inertness of soapstone has led to its wide use for laboratory equipment; in fact, many modern laboratories are completely furnished with soapstone table tops, sinks, drain boards, gutters, fume hoods, shelving, floors, and tanks as well as miscellaneous special equipment. Similar use of the stone is made in acid and other chemical plants for vats, floors, shelves, wainscoting, and other parts of the plant which may be subjected to the destructive action of chemicals or fumes. These applications consume only about 10 per cent of the total volume of soapstone produced.

The use of the stone in dye plants depends upon its low absorption as well as its chemical inertness. When soapstone tanks are used, it has been found possible to change from one color to another with no appreciable contamination by merely rinsing the tank thoroughly between solutions. These properties have encouraged its use in storage tanks for acid or alkali solutions. Surface stains are removed easily by "Carborundum" honing or sandpapering.

In addition to the laboratory equipment already mentioned, soapstone is used for a variety of purposes in which the general adaptability of the stone is more important than its specific property of acid or alkali resistance. Among these uses are for photograph, blueprint, X-ray, and cardiagraph developing tanks; autopsy, mortuary, and mausoleum slabs; animal kennels and cages, particularly for hospitals and related institutions; and miscellaneous equipment for all types of research laboratories.

A good description of the use of soapstone in the paper industry is given in "Talc and Soapstone in Canada" by Spence.[3]

> One of the most extensive uses of block soapstone is for lining the smelting furnaces of sulphate (kraft) pulp mills. In such mills, furnaces are used to smelt the black ash formed during the initial stage of recovery of the alkali in the waste liquor from the digesters. These furnaces are of stationary type and are lined with

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[3] - Spence, H. S., Talc and Soapstone in Canada: Canada Dept. Mines, 1922, p. 55.

soapstone. Into them is introduced the black ash, mixed with sulphate of soda and sawdust, and the whole is then burned, the fused alkali being run out into a dissolving tank.

In addition to its resistance to fire and alkali under such conditions, soapstone has the merit of offering a surface to which the fused alkali will not adhore, and thus the furnace walls do not require to be cleaned. *****

The requirements in a soapstone for sulphate pulp furnaces are: fine to medium grain, compactness and homogeneous composition, and freedom from flaws and cracks. It should consist largely of talc, and contain no carbonates (dolomite, calcite) or pyrites. The stone should possess a massive, as opposed to a schistose texture, since schistose soapstone tends to spall readily and has little strength.

The discovery of a soapstone possessing the above characteristics, in Canada, would be of considerable benefit to domestic paper mills, since the quantity used is large and the cost of the imported stone high - from $5 to $6 per cubic foot, laid down.

The soapstone bricks used vary in size. Common dimensions are: 12 x 12 x 6 inches; 12 x 6 x 6 inches; 12 x 6 x 3 inches; 18 x 12 x 8 inches; 18 x 12 x 12 inches.

Before 1910 virtually all soapstone used in American paper mills was imported from Sweden. The American mills were gradually learning the advantages of dealing with an American source of supply when the World War brought on chaotic trade conditions which accelerated the change already taking place. Actual use of stone from the Virginia deposits showed that it was satisfactory in quality and that the service from domestic sources was superior to that from imports. Consequently, this use has increased until it now comprises about 40 per cent of the total output.

The other common uses of soapstone are more dependent upon its physical properties than its chemical composition. Laundry tubs and kitchen sinks are the oldest representatives of this group. They were first made at Alberene, Va., about 60 years ago. For more than 50 years, they represented the greater part of the soapstone business. Within the past 10 years, however, the laundry tub market has decreased until now it comprises only about 10 per cent of the total volume of soapstone production. Competitive materials, electric washing machines, partial saturation of potential markets, promotional activities of laundries, and the trend toward apartments have been responsible for the slump in the demand for laundry tubs. The sale of tubs finished in bright colors has aided in meeting the desire for color in home furnishings.

The durability, uniformity, workability, comparative nonabsorption, and neutral color of soapstone make it desirable for numerous architectural adaptations. The increased use of soapstone in building construction during the past few years has more than offset the decline in laundry tub production.

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Large quantities of soapstone have beenused for sanitary partitions, shower compartments, sills, interior trim, wainscoting, spandrels, and exterior trim. Two other important architectural uses, stair treads and floor tile, are the principal outlets for the hard grades. The use of soapstone in combination with marble and other decorative stone is being actively promoted at present. The greatest possibility for expansion of soapstone production is generally acknowledged to be through the increased use of the stone for various architectural purposes. In fact, at present soapstone logically should be included in any discussion of the dimension stone industry. The volume of production is small when compared with other more common building stones, but in its particular field, soapstone is of noticeable importance.

The high dielectric strength of soapstone, combined with its uniform texture, low absorption, freedom from metallic veins, resistance to flame action and high mechanical strength, makes it an especially desirable material for electrical insulation. Here again, however, the advantage of easy workability must not be underestimated, for the rapidity and accuracy with which soapstone can be machined undoubtedly is directly responsible for much of its popularity among electrical manufacturers. It is used for switchboards, panels, barriers, bases, circuit breaker compartments, insulating floor slabs, battery room shelving or flooring, and for other related purposes.

The high heat-retention properties of soapstone led to its use as potstones and cooking utensils by both the Indians and the early American settlers. Until the last few years an appreciable part of soapstone production was utilized in the manufacture of griddles, fireless cookers, oven floors and grates, footwarmers, snow melters, and hearths. At present, however, more modern contrivances have supplanted most of these products although soapstone still is being used in large commercial travelling ovens and electrical fireless cookers.

When heated to a temperature of about 1,800° F., some grades of soapstone turn to a golden brown color and become so hard that they can not be scratched with an ordinary knife. Considerable research work has been done in attempts to utilize this property commercially in the production of floor tile or decorative stone for use where hardness and durability are important factors. Results obtained in using the material have been entirely satisfactory, but manufacture is difficult. The principal constituent minerals of soapstone contain water of crystallization which is driven off at varying temperatures, depending upon the exact composition. In order to avoid cracking while the soapstone is being heated, the temperature must be held constant for several minutes at the critical point or points of the particular sample. Obviously, in mass productic with varying critical temperatures this is impractical and, as a result, in the manufacture of such tile a heavy loss is incurred because of fracturing.

A modification of this same principle which apparently has possibilities is heating of soapstone dust, the resultant product to be used as an abrasive. Various grades and sizes could be produced. The process is patented, but no commercial utilization has been attempted.

Only an insignificant part of soapstone waste is now being utilized profitably. Small quantities of irregularly broken slabs are used locally in landscaping as stepping stones or for rock gardens. Unfortunately, the isolated location of the deposits prevents extensive development of this market possibility. Soapstone has been used in Schuyler and vicinity for masonry construction. Crushed soapstone has been used satisfactorily as concrete aggregate, but this outlet logically is confined to local utilization.

The only outlet for waste soapstone of any appreciable size or importance is in pulverized form. Ground soapstone has been used for a variety of purposes in direct competition with other pulverized rock including the lower grades of talc. It does not compete with high-grade talc, especially for uses in which color is an important factor. At present the rubber and roofing trades are the largest consumers. It is used principally for dusting raw or processed material in various stages of manufacture to prevent sticking, although it is reported that some of it may be used as a filler. Considerable quantities are exported; one large rubber company in Singapore using it for dusting raw rubber to be shipped into this country. Much of the tire powder used to sprinkle between casings and inner tubes is ground soapstone.

Ground soapstone has been found to be satisfactory for rock dusting of coal mines, a precautionary measure extensively used in the coal mining industry to prevent the spread and the occurrence of coal-dust explosions. However, in most mining districts competition from low-priced ground limestone is severe. The extremely low absorption of soapstone should be desirable in connection with rock dusting, but no studies have brought out this feature.

The use of admixtures in concrete has attracted much attention during the past few years. Numerous products have been introduced, all of which claim increased workability and denser concrete as their principal advantages. Ground soapstone has been used successfully for this purpose, but no attempts have been made to promote its distribution on a large scale.

The manufacture of floor tile made of ground soapstone, sawdust, and Portland cement, appears to be worthy of further research. This type of flooring combines resilience and durability, and it is especially adaptable to industrial buildings. Its commercial development no doubt would stimulate production of ground soapstone.

GEOLOGY

Although numerous authorities have studied the geology of soapstone, it is generally agreed that much additional work must be done to determine its origin in detail. The consensus, however, is that soapstone is secondary, having been formed usually by the alteration of a basic igneous rock. Such rocks necessarily would have to be high in magnesia; as for example, pyroxenite, amphibolite, dunite, or peridotite. In some minor occurrences, soapstone has resulted from the metamorphosis of dolomitic limestone. Most deposits characteristically occur in long narrow belts roughly parallel to the general trend of the country rock. This orientation suggests derivation from sedimentary rocks, but additional evidence in many localities virtually proves that the soapstone bodies are dikes rather than strata.

The soapstone deposits near Schuyler, Va., occur as lenses and irregularly shaped, elongated bodies lying in or along the edges of larger intrusions of partially metamorphosed gabbro or pyroxenite. Cambrian schists predominate throughout the region. The general strike of the schists is from N. 40° E. to N. 60° E., and the dip varies from 50 to 80° to the southeast. Both the meta-igneous intrusions and the soapstone dikes lie roughly parallel to the strike of the country rock, although locally this orientation may vary. The soapstone lenses range in size from virtually nothing up to immense bodies 1,500 to 2,000 feet long and 300 feet wide. Their depth is not known. At the present rate of production, there is enough available soapstone at and near Schuyler to last for 50 to 100 years.

Burfoot[4] has made a comprehensive study of the origin of the talc and soapstone deposits of Virginia. His complete report ultimately will be available as a bulletin of the Virginia Geological Survey. In an interesting paper originally presented at the 1929 annual meeting of the A.I.M.E., Ryan[5] discusses the geology of Virginia soapstone, especially with reference to mining problems. These references should be consulted for additional information on the origin and geology of soapstone.

GEOGRAPHICAL DISTRIBUTION

The existing confusion in the use of terms "talc," "steatite," and "soapstone" makes it extremely difficult to correlate reports of deposits with soapstone as it commonly is known. In referring to some foreign deposits, the terms apparently are used interchangeably.

Virginia has virtually a world monopoly on the production of slab and block soapstone. The principal Virginia deposits form a large belt which extends through Nelson, Albemarle, and Orange Counties. At present, all operations are centered at Schuyler, which is in Nelson County only a short distance from the Albemarle line. Minor deposits of soapstone occurring in association with talc have been worked in Fairfax, Franklin, Amelia, and Henry Counties.

Soapstone has been produced in Vermont, Maryland, North Carolina, Rhode Island, and New Hampshire, but all these operations have long since been abandoned. Little is known regarding any of these deposits, but cessation of activity apparently was caused in most instances by a combination of technical and economic difficulties. In 1930, soapstone production was reported in California, but available information regarding it indicates that it more properly should be classified as talc. A large deposit of soapstone reported near Benton, Arkansas, never has attracted much attention because of its inaccessible location.

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[4] - Burfoot, J. D., jr., The Origin of the Talc and Soapstone Deposits of Virginia: Jour. Econ. Geol., vol. 25, 1930, pp. 805-826.

[5] - Ryan, C. W., Soapstone Mining in Virginia: Am. Inst. Min. and Met. Eng., Tech. Pub. 160, 1929, 31 pp.

The Canadian paper manufacturing industry constitutes an important market for block soapstone, much of which now is supplied from the United States. Since about 1924, however, considerable interest has been shown in the Canadian deposits, and production has been reported from the Lake of the Woods region of western Ontario and from the Province of Quebec. These deposits are located relatively close to many of the large paper mills, and it is reasonable to expect increased production, possibly to the ultimate exclusion of Virginia stone.

Deposits of soapstone in the Scandinavian countries have been worked for many years, principally for furnace blocks and structural purposes. Numerous occurrences of soapstone have been reported in India, China, and other countries, but none has been developed commercially except as a local source of foot-warmers, carved ornaments, grates, or similar minor commodities.

PROSPECTING

No development work in any soapstone deposit ever should be attempted without complete knowledge of its extent, quality, and uniformity. A careful scrutiny of outcrops will reveal something of the nature of the stone and the value of such a reconnaissance is considerable, but additional information generally is necessary to determine the actual worth of the deposit. Ryan's[6] opinion is worth consideration.

> The study of surface indications can give at best only approximate ideas as to the nature of the underlying stone. The best indicator is the outcrop of uniform resistance to the elements, with an even distribution of talc and a relative freedom from carbonate impurities. The core drill must be relied upon to verify or nullify these indications.
>
> Formerly a series of trenches was dug at promising locations to uncover the outcrop more completely, as it was thought that a more satisfactory study of the qualities of the stone could be made in that way. This method is expensive and can not compare with core drilling, either in cost or scope of information obtained. The diamond drill will show the conditions at depth, will indicate the proportions and nature of the various grades of stone, and will give some information of fissures.

The value of consulting the State geologist should not be overlooked. Many States maintain a well-equipped, competent geological survey, the members of which may have accurate geologic knowledge of the deposits in question. Ordinarily this service is free, and the information received may prevent unwise expenditures both in prospecting and development.

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6 - Ryan, C. W., Work cited, p. 17.

If a preliminary investigation appears to justify the expense of developing the deposit, a competent engineer should be employed. His duties should be twofold; first, to check the results of the original prospectors and enlarge on that information; and second, to supervise the actual development. The importance of this procedure can not be overestimated.

QUARRYING

The limited scope of this report prohibits a detailed discussion of soapstone quarrying methods. However, the problems are virtually identical to those encountered in marble quarrying, except that soapstone is softer and no attention has to be given to the position of markings like those which enhance the value of polished marbles. On the other hand, the softness of soapstone necessitates extreme care in handling it. An excellent discussion of all phases of quarrying and preparation of marble is given in a paper by Bowles.[7] This report no longer is available for distribution, but it can be consulted in most libraries.

The paper by Ryan[8] is devoted directly to the mining of soapstone. Numerous other articles of lesser importance on various phases of the industry have been published in trade journals. The following brief discussion describes practices at Schuyler, Va., the home of the only active producing company.

The normal size of quarries at Schuyler is 100 feet long by 100 to 120 feet wide. The actual width is governed by the size of the dike. Sufficient soapstone to provide a good face is left in place along the hanging wall. When a series of quarries is opened along the dike, pillars 22 feet wide are left standing between operations. The top five or six floors of these pillars may be salvaged, but usually they are left standing to support the walls of the abandoned quarries. The ultimate depth of any quarry depends directly upon the condition of the walls. Some operations have been abandoned when only about 100 feet deep, but the average depth is nearly 200 feet. The deepest quarry over operated at Schuyler was 271 feet.

The soapstone operator should have a thorough understanding of wall conditions, for the safety of the men working in the pit depends directly upon him. Quarry walls like mine roofs rarely give way without showing preliminary evidences of weakness. A superintendent with mining experience is an asset in soapstone quarrying for sound knowledge of conditions in the pit not only may avoid serious accidents, but also may permit deeper working of quarries which under less competent management would be abandoned at some arbitrary depth.

The method as well as the expense of opening a new quarry depends directly upon local geologic conditions. Overburden generally is removed by steam shovels and drag scrapers. No explosives are used during either development or quarrying. Hydraulic stripping has been used in some instances but not extensively. Occasionally, conditions are such that good stone is found on the top floor, thereby greatly reducing the quantity of waste stone to be handled. More commonly, however, the first seven or eight floors are principally waste.

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[7] - Bowles, Oliver, The Technology of Marble Quarrying: Bull. 106, Bureau of Mines, 1916, 174 pp.

[8] - Ryan, C. W., Work cited.

Disposal of overburden and waste rock is an important problem in the soapstone industry. Dumps near operating quarries tend to aggravate the stress upon the quarry walls. It is desirable, therefore, that waste material be dumped where it will not interfere with present or future operations. The most satisfactory method is to fill abandoned pits with the refuse from newly opened quarries. Mill waste also must be considered, for only about 20 per cent of the quarry output emerges from the mill as finished product. Under favorable conditions, this material may be disposed of economically by dumping it into nearby abandoned quarries.

After the overburden is removed, quarry operations are commenced by channeling across the strike with either steam or electric-air channeling machines. The distance between channel cuts varies from 4 to 6 feet and the average depth is $6\frac{1}{2}$ feet. The center cut is broken out first, and thereafter all channel cuts are undercut to their full width. The undercutter is a reciprocating machine which works on exactly the same principal as the channeler. It makes a cut slightly inclined from the horizontal. A Jeffrey longwall undercutter equipped with Stellite teeth is being used satisfactorily for undercutting in quarries producing "soft" stone.

When the entire width of the quarry has been channeled and undercut, one end of the section is channeled and the end block is broken out. All blocks except the end ones are roughly diamond shaped because all breaks are induced along the natural grain of the rock, the dip of which may vary from 30 to 60°. The blocks are broken out by drilling a series of holes along the natural parting planes of the rock and then splitting by wedging. The size of the resultant diamond-shaped blocks is roughly 4 by 4 by 6 feet or slightly larger. Irregularly shaped or considerably larger blocks may be quarried for special purposes. Each block is graded according to hardness, color, and soundness. The uses for every block depend upon its grade. Swinging boom derricks are used to lift the blocks from the quarry floor and to place them on cars or stock piles, depending upon the current mill requirements.

MILLING

The first step in the preparation of soapstone is gang sawing of the blocks. The spacing of cuts depends upon the uses for which each block is intended. A high percentage of the material is sawed into thin slabs, therefore, the diamond shape of the blocks is not conducive to excess waste as would be the case if large square or rectangular blocks were the ultimate product. Furthermore, for most uses the stone must be sawed parallel to the rift.

There are 38 gangs at Schuyler, the actual number in operation at any time depending upon the mill output. The saws are semiautomatic, one man operates a battery of four. Sea sand, principally from Norfolk, Virginia, is the abrasive commonly used; minus 30 plus 46 mesh has been found to be most satisfactory. The sand is recovered through a trap at the bottom of each gang and used over and over, fresh sand being added at the discretion of the operator. In normal times 5 or 6 cubic yards of sand a day is sufficient to supply all saws.

Each blade of a gang is a steel strip 3½ inches wide by 12 feet long and 1/8 inch thick. This length blade with an 18 inch stroke can be used to saw a block up to 10 feet in length. The average speed of sawing during the day is 84 complete strokes a minute, but at night when there is no power load at the mill the speed steps up to about 100 strokes. The rate of cutting varies considerably with the grade of the stone, but it averages about 4 linear inches an hour. In normal practice it takes a little more than one 12-hour shift to saw a 65-inch block.

Slabs are taken from the gang saws either to the stock mill or to the custom mill. The cut blocks are handled by an overhead crane, while in the mill individual slabs are conveyed by a monorail system. The stock mill produces routine, standardized products such as laundry tubs, sinks, and furnace block

Slabs to be used for laundry tubs are trimmed with a steel-toothed band saw similar to those used in woodworking. Laundry tub slabs are gang-sawed 1/8 inch thicker than the finished product. Therefore, after trimming each slab is taken to a rubbing bed where the excess thickness is removed and a rubbed finish is imparted to the stone. A cast-steel bed 4 inches thick and 46-mesh crushed steel abrasive are the principal features of this equipment. The life of each bed is from 2 to 3 years. By means of an eccentric the stone is moved back and forth across the bed in order to prevent grooving and to insure uniform wear on the bed itself. After having been tongued and grooved by "Carborundum" machines and smoothed by "Carborundum" finishers, the slabs are ready for the assemblers.

One small bolt in each corner is used in assembling laundry tubs, but no part of it is exposed in the interior. Putty made of linseed oil, litharge, and a small percentage of whiting binds the tubs together. This putty expands as it seasons, thereby insuring water-tight joints. In summer it requires only 6 to 10 days to set properly, but in cold, damp weather it may take 2 months for its final set. Plaster of Paris is used to relieve the strain on the bottoms of the tubs while the putty is seasoning.

Soapstone, like marble and other ornamental stones, must be handled carefully. Fortunately, however, small fractures can be repaired so effectively that the break is unnoticeable. German marble cement is used to patch broken corners or similar fractures. The slab is rubbed smooth at the break, and a piece of soapstone matching it in color and texture is smoothed to fit the surface of the slab. They are cemented, and the repair piece is honed down to conform with the shape of the original slab. The cement ordinarily is stronge than the stone itself, and the repair can be detected only by minute observati when the stone is wet. A patching cement made by mixing soapstone dust with marble cement is used to patch small breaks or to fill up holes which have been gouged into the stone. This cement is heated and pressed into place. When cool, the roughness is sanded off and the repair is found to blend perfectly with the stone. A few of the old-timers in the mill are experts at mixing and using this patching material.

A very important function of the stock mill is the production of furnace blocks for use in paper manufacturing plants. Numerous sizes and shapes varying from 3 inches to 3 feet are produced. All cutting is done by a circular diamond saw. The most important consideration in the manufacture of furnace blocks is the grain of the stone. Blocks laid in the furnace with the grain parallel to the exposed surface would spall, thereby giving unsatisfactory service.

At present all other soapstone equipment is fabricated to specifications in the custom mill. The general procedure is similar to the stock mill except that blueprints are followed on all jobs. Furthermore, much stone used for the products of the custom mill is harder than that used in laundry tubs; as a result, "Carborundum" circular saws rather than steel are used for trimming "Carborundum" grinders supplement rubbing beds; usually one side is levelled on a rubbing bed after which the slab is ground to the proper thickness on the "Carborundum" machine. Each slab then passes a checker who designates from blueprints the additional fabricating work to be done. Joiners, drill presses, and similar equipment are used to complete the preparation of each piece. The actual assembling of the slabs is done either in the mill or on the job, depending upon the nature of the order. In either event, the linseed oil and litharge cement commonly is used. Throughout the entire procedure similarity to woodworking methods is strikingly evident. This, of course, is due to the nature of the stone and the ease with which it may be fabricated.

A small part of the better-grade waste soapstone is ground in a mill at Damon, Va., about 4 miles from Schuyler. This mill has been designed for flexibility of product. A gyratory crusher reduces the stone to 1 inch. It is then screened, the fines passing directly to an Allis-Chalmers ball mill while the coarse split goes through a Pennsylvania hammer mill, which reduces it to about 1/4 to 3/16 inches, before passing to the ball mill. Hum-mer screens are used for the next sizing, the mesh depending upon the product desired. Oversize goes through an Allis-Chalmers tube mill, and the fines from both are subjected to air classification to collect the ultimate product, 97 per cent of which passes 300 mesh. The most important product of the mill is minus 40 plus 48 mesh, which is used extensively in the rubber industry.

MARKETS AND PRICES

Soapstone is sold by the producer (through a selling company) direct to the consumer. There are virtually no merchants, middlemen, or independent fabricating plants. Small quantities of rough blocks have been marketed sporadically in past years, but the outlet for raw material is inconsequential. Markets for soapstone are world wide, but only a small proportion of present production is exported. The largest consumption in the United States is east

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of the Mississippi within reasonable shipping distances of Schuyler. In recent years the increased use of soapstone for architectural purposes has resulted in a seasonal fluctuation in demand paralleling that of the building industry.

Schuyler is somewhat isolated and therefore all soapstone is shipped by rail. Whenever practical it is shipped in carload lots; the minimum carload being 24,000 to 36,000 pounds. Most soapstone, except furnace blocks, is transported in strong crates to aid in eliminating the hazards of breakage in transit. Slab stone commonly is shipped on edge, for the possibility of breakage is less than when placed flat on the bottom of the car. Few shipments are insured.

The fact that the production and sale of soapstone is in the hands of a single company does not mean that competition is nonexistent. Actually, soapstone meets strong competition from other products in virtually every field.

The prices of soapstone are directly dependent upon the sales prices of competitive materials as well as upon the cost of quarrying and fabrication. Crude soapstone is worth only slightly more than the cost of production; therefore an undeveloped deposit has little value unless it is so located that it would have decidedly advantageous freight rates to marketing centers.

The present unit of measurement for manufactured soapstone is 1 square foot, 1-1/4 inches thick. All products, regardless of their size, shape, or use, are reduced to these units. Furnace blocks comprise the largest low-priced outlet, while complicated developing tanks and similar equipment bring the highest prices. The present range is from $0.30 to $1 a square foot. This is equivalent to $30 to $100 a ton.

PRODUCTION

Figures for soapstone production since 1924 are not available for publication. The accompanying table, however, gives a summary of production from 1916 to 1924.

Soapstone sold by producers in the United States, 1916-1924[1]

Year	Short tons	Value
1916	19,127	$ 489,606
1917	19,885	402,506
1918	12,330	501,059
1919	16,504	530,163
1920	19,707	709,400
1921	17,423[2]	627,826[2]
1922	22,700	712,144
1923	22,857	932,098
1924[3]	25,630	1,288,885

1 - Compiled from Mineral Resources of the United States.
2 - Includes sawed and manufactured talc.
3 - Figures since 1924 not available.

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A summary of the relation between output and uses is given in the accompanying table. It is interesting to note that the two principal outlets for soapstone in 1930 were of little importance in the early years of development of the industry.

Principal outlets for soapstone showing proportionate production, 1900-1930, per cent

Use	1900	1910	1920	1930
Laundry tubs (includes sinks)	85	75	59	10
Furnace blocks	0	0	4	40
Special (includes architectural)	15	25	37	50
Miscellaneous	-	-	-	Less than 1

IMPORTS AND EXPORTS

With the exception of Swedish furnace blocks and Chinese carvings, virtually no soapstone ever has been imported, and exports have been confined principally to shipment of furnace blocks to Canada. Foreign production is in no way comparable to the domestic output. Small quantities of soapstone have been produced in Great Britain, Norway, and Sweden. France, Spain, and Germany are reported as having produced soapstone or steatite; but the figures are included with talc, and apparently the soapstone is of little consequence. Canada is now producing soapstone principally in the form of furnace blocks. As yet, however, the Canadian output apparently is not sufficient to meet the needs of the extensive paper manufacturing industry, for considerable quantities of furnace blocks are shipped into Canada from Schuyler.

TARIFF HISTORY

Under various tariff acts soapstone has been dutiable, if imported, at the same rates as talc. The present duties are listed in paragraph 209 of the tariff act of 1930, which reads as follows:

> Talc, steatite or soapstone, and Franch chalk, crude and unground, one-fourth of 1 cent per pounds; ground, washed, powdered, or pulverized (except toilet preparations), 35 per centum ad valorem; cut or sawed, or in blanks, crayons, cubes, disks, or other forms, 1 cent per pound; manufactures (except toilet preparations), of which talc, steatite or soapstone, or French chalk is the component material of chief value, wholly or partly finished, and not specially provided for, if not decorated, 35 per centum ad valorem, if decorated, 45 per centum ad valorem.

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ECONOMIC CONSIDERATIONS

The history of the soapstone industry in the United States is that only one operator has been able to survive. Others have entered the field, but one by one they have dropped out. A survey of the situation reveals several factors which may have been responsible, at least in part, for the failure of former producers. The value of any deposit depends not only upon the quality of the available stone, but also upon its location and extent. Competition from other materials is felt keenly in the marketing of soapstone; slate, marble, concrete, and ceramic materials are the principal competitive products. At best, the total annual volume of material marketed is small; and since it is virtually all in the form of fabricated products, a completely integrated plant comprising extensive milling equipment is needed as well as the usual quarrying machinery. This involves a heavy investment. In the case of a new operation, an even larger expenditure may be required before consumers can be induced to accept a new product. Under these circumstances it should be evident that mere possession of even a good deposit does not in itself indicate that it will be profitable for a newcomer to enter the soapstone industry.